Tschudi dans la description de la *M. agilis*. Le poil des parties inférieures est unicolore. Les griffes sont blanchâtres. Dimensions en millimètres :

	♂.	♀.
Long. depuis le nez jusqu'à la naissance de la queue	270	270
„ de la queue avec le poil	185	175
„ de la queue sans poil	150	173
„ de la tête	60	60
„ du tarse avec les griffes	51	51

C'est l'espèce la plus voisine de la *M. frenata* du Mexique ; la grandeur est presque la même, ainsi que la proportion de la queue, qui est aussi presque également velue, terminée en pointe et non pas en pinceau comme dans la *M. erminea*.

Sans doute c'est l'animal mentionné par Tschudi*, il dit : "Nous supposons que plusieurs différentes espèces s'y trouvent, car nous avons vu plusieurs fois une belette près de deux pieds de longueur, sans avoir eu le bonheur de la tuer. Les renseignements des Indiens confirment notre supposition." Notre animal est plus petit, car il n'a que 18 pouces, mais Tschudi a pu exagérer sa grandeur en comparant avec *M. agilis*.

3. Notes on the Respiration of some Species of Indian Freshwater Fishes. By G. E. Dobson, B.A., M.B., C.M.Z.S., F.L.S.

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The following notes on the respiration of some species of Indian freshwater fishes were derived from experiments made in the months of April, May, and June last year upon several specimens from the river Hooghly, near Calcutta. The number of species examined was eleven, representing six families—namely, Siluridæ, Symbranchidæ, Cyprinidæ, Labyrinthici, Ophiocephalidæ, and Mastacembelidæ.

Previous observers † of the habits of the freshwater fishes of tropical countries had remarked that some species required atmospheric air directly for the purpose of respiration, and if prevented from obtaining it were suffocated, precisely as land animals would be. To such species the term "aerial" or "compound breathers" has been applied, in contradistinction to that of "water-breathers," which is applicable to most species of fishes.

* Fauna Peruana, Säugeth. p. iii.

† To avoid entering upon an account here of what has been observed on the same subject previously, it will be sufficient to refer to Mr. Boake's paper on the fishes inhabiting the Ceylon marshes, published in the Journal of the Ceylon Branch of the Royal Asiatic Society, 1865, and to Mr. Francis Day's paper entitled "Observations on some of the Freshwater Fishes of India," in P. Z. S. 1868, pp. 274–288, in which, besides an account of many most interesting and original experiments on the respiration of these fishes, the investigations of previous observers are described or referred to.

The following experiments were undertaken with the view of extending our knowledge in this direction, by determining what other species are compound breathers, and in what degree the direct use of atmospheric air is necessary for their existence.

The manner of conducting the experiments was similar to that adopted by Mr. Francis Day *, to whose investigations these notes may be regarded as addenda.

The specimens experimented upon were recently taken and quite uninjured. The temperature of the water during the period occupied in making the following observations varied very slightly, from about 87° to 91° Fahr.

Exp. 1.—A specimen of *Plotosus canius* was placed in a large cylindrical glass jar (of equal diameter throughout) nearly filled with water, and having a metal plate, pierced throughout with large openings, fixed 1 inch beneath the surface of the water. The metal plate was fixed in this position immediately after the fish had been observed to rise to the surface of the water. Twelve minutes afterwards the fish again rose and pushed violently against the plate, but not succeeding in getting to the surface it sank slowly to the bottom of the jar. Having remained thirteen minutes at the bottom rapidly moving the gill-covers, it made a second attempt to reach the surface, and dashed so strongly against the plate as to force it upwards, and so obtained access to the air. On sinking down again, a large number of air-bubbles passed upwards from the gill-openings.

The fish was then placed for the night in a large earthenware basin, with a specimen of *Ophiocephalus punctatus* about the same size. Next morning the latter had eaten the greater portion of the barbels of the former, and had torn away the skin of the abdomen. The greater portion of the anal fin was detached from the body and eaten, but the fish seemed as lively as before. Two other fish of the same species had leaped out of another basin, and were found dead on the floor. The *Plotosus* was again placed in the same glass jar, having a diaphragm of net fastened $1\frac{1}{2}$ inch below the surface of the water. It remained inactive for nearly half an hour, then sought the surface, but being repulsed by the net struggled violently against it, during which time several air-bubbles passed from the gill-openings to the surface of the water. It died in one hour from the time of being first placed in the jar, and in half an hour from first commencing its struggles.

Exp. 2.—Placed four specimens of *Macrones tengara* at 10.40 A.M. in the glass jar, the netted diaphragm being fixed as in Exp. 1. In another jar without a diaphragm two specimens were also placed. At 3 P.M. the respiratory action of the fish in the jar with the diaphragm became much excited; at 3.40 the largest individual, which had been for some time swimming about, rose to the net and pushed against it several times; at 4.40 all the fish had almost

* *Loc. cit.* p. 278, exp. 1 & 4.

ceased to respire, and lay at the bottom of the vessel. To show that their deaths were not due to a deleterious condition of the water, it was carefully drawn off (a small portion sufficient to cover the fish being allowed to remain) and fresh substituted, without, however, permitting the fish to reach the surface. The fresh water seemed to produce no change in their condition. At 5 P.M. the largest specimen lay on its side; at 7 P.M. all were dead. Both the specimens in water with free access to the surface were alive at this hour; but one died at 10 P.M., probably from wounds it had received; the other was found dead next morning*.

Exp. 3.—A specimen of *Saccobranchus singio* was placed in the same jar, having the netted diaphragm similarly fixed 1 inch beneath the surface of the water. It made but few attempts to reach the surface, and died in four hours. Another specimen placed in the jar afterwards swam about in a very lively manner, and made several attempts to reach the surface of the water; it died in two hours.

The difference in the time required to cause suffocation was probably due to the greater exertions made by the second specimen, which exhausted the supply of air faster.

Other specimens kept for observation in my aquarium with free access to the air were observed, when approaching the surface of the water, to discharge a considerable amount of air from the gill-openings, immediately afterwards placing the muzzle above the water.

Exp. 4.—A specimen of *Amphipnous cuchia*† was placed in the glass jar, which was more than half filled with fresh water. The netted diaphragm was omitted, in order to observe its mode of respiration. The habits of the animal while in the water were noted during eight days, with the following results:—It was found that the fish either lay in a semitorpid state at the bottom or remained suspended in the water, keeping its head resting against the side of the jar about 1 inch or less below the surface. The used-up air was expelled from the gill-apertures, at first slowly, one bubble succeeding another till four or five were discharged; the remaining air was then expelled by a single effort, the fish immediately sinking to the bottom of the jar, most probably as the direct result of suddenly increased specific gravity. Usually in about two minutes afterwards the animal raised itself by muscular effort, placed the muzzle at the surface of the water, separated the lips slightly (precisely as a snake does when

* I do not consider the above-described experiment as conclusively proving this species to be a mixed air- and water-breather; for although very many specimens were procured by me for the purpose of examining their respiration, the greater number died before I could find an opportunity for making the necessary experiments; and even those examined were most probably in a sickly condition, as shown by the death of the other two specimens, not confined beneath the surface of the water, a few hours later. When placed in the aquarium these fish invariably kept swimming round and round, having the extremity of the muzzle at the surface of the water, or remained vertically suspended with the mouth at the surface. This seems to me to indicate that unmixed air was also required for the purpose of respiration.

† For a description of the respiratory organs in this fish, see Owen's 'Anatomy of Vertebrates,' vol. i. pp. 481 & 487.

about to hiss), and took in air, the branchial sacs behind the commissure of the lips becoming inflated *.

The fish was, on the ninth day, removed from the water and placed in a basket with some moistened grass. It lived there for five days without water. Unlike other fish kept for experimental purposes, it refused food of any description during the whole time it remained alive.

Exp. 5.—A specimen of *Lepidocephalicthys balgara* was placed in the glass jar, which was half filled with fresh water. No diaphragm was used. The fish was observed to pass to the surface of the water rapidly, and apparently blow off from the mouth some air-bubbles. It immediately retreated to the bottom, and there the action of the gill-covers was exceedingly rapid, so rapid as to be impossible to count, perhaps 200 in a minute. It was seen but on two occasions to go to the surface during the whole day; but from the presence of bubbles on the surface it was suspected that it went on many other occasions when not observed.

The glass jar with the fish in it was taken for the night into my bedroom. About one o'clock I was awakened by some noise, and heard a sound between a grunt and a squeal. I thought a Rat had got into the room (a not uncommon occurrence in the East), and lit a candle to see where the intruder was. On going to that part of the room whence the sound proceeded, I was surprised to find that my little fish was the cause of all the disturbance. He had leaped out of the glass jar (the edge of which was 3 inches above the surface of the water), and had fallen to the ground, a distance of 4 feet. I found him wriggling about in the dust, occasionally uttering a squeal. On taking the fish into my hand he again made the same noise, which is very peculiar.

On the following evening the same fish remained in the glass jar without water from 8 P.M. to 10.30 P.M., and on being again placed in water appeared to have sustained no injury. When placed in shallow water it remained suspended in the water, its head just beneath the surface, respiring very rapidly. It supported itself in this position by resting on its tail and lying against the side of the vessel, precisely as *Amphipnous cuchia* in Exp. 4.

On the approach of any object close to the side of the vessel, the fish always turned its head towards the object, and the gill-covers ceased to move, the animal regarding the intruder intently for some time; then, when satisfied that no immediate harm was to be feared, the action of respiration was resumed, the gill-covers moving as rapidly as before.

Two days after its attempt to escape at night the same fish (which appeared quite as lively as when first obtained) was placed in the same glass jar. A double net was stretched about half an inch beneath the surface of the water. Fifteen minutes afterwards the fish suddenly rose and attempted to reach the surface, then sank

* The branchial sacs in the inflated condition appear to act also as floats, retaining the head of the animal near the surface of the water in a convenient position for capturing its prey.

down, and again renewed the same attempt more vigorously. Five minutes afterwards it rose again, and pushed strongly against the net. Thirty minutes afterwards it swam about excitedly round and round the vessel. Two hours subsequently, in some way I did not perceive, it splashed water up through the double net violently, so that some drops fell outside the jar, the mouth of which was nearly 4 inches above the surface of the water. Fifteen minutes afterwards I saw the fish resting vertically on the extremity of the caudal fin, having its head thrust through one of the meshes of the lower net, and the extremity of the snout at the surface of the water through a mesh of the upper net. The depth of the water was such that the fish exactly reached the surface with the snout when suspended vertically resting on the tip of the caudal fin.

The netted diaphragm was now raised 1 inch higher, and water added, so that the net was 1 inch beneath the surface. In thirty-seven minutes the fish again sought the surface, and succeeded in thrusting its head and part of its body through the meshes of both nets, so that its muzzle rested at the surface of the water. In this position it remained quiet, apparently drawing in the unmixed air, and would only leave its position when touched several times. Soon afterwards it again forced its way through the net as before; and two minutes afterwards some bubbles of air passed from its mouth. On shaking the vessel some air-bubbles passed upwards from the gill-openings.

The net was now removed and a perforated tin plate substituted. In forty-five minutes the fish swam about in an excited manner, and then sank to the bottom. It made several attempts to reach the surface, and at length managed to force itself through a somewhat larger opening in the centre of the plate, which I had thought much too small for it to get through. Immediately on reaching the surface it discharged a large amount of air under water, as a great number of bubbles came up about it. It remained in shallow water (about half an inch deep) all next day, and appeared very lively in the evening. On the following day I observed that soon after taking in air at the surface and sinking to the bottom of the vessel, a large amount of air passed upwards in bubbles from the anus.

The fish was removed to a larger jar, fresh water placed in it, and a tin plate pierced throughout with openings of an equal size, too small to allow the animal to gain access to the surface. The fish made many attempts unsuccessfully to reach the surface, and at length sank to the bottom and remained quiet there, the gill-covers moving, however, very rapidly. In twenty-four hours the fish was evidently about to die; the dorsal fin had collapsed, and the gill-covers had almost ceased to move. The diaphragm was removed, and fresh water placed in the jar. The fish immediately recovered strength, the dorsal fin became erect, and respiration proceeded as before. On the following night he again leaped out of the jar, and was found dead on the floor next morning.

Exp. 6.—Another specimen of *Lepidocephalicthys balgara* was placed in the glass jar in about 3 inches of water without the

diaphragm. It remained for a long time vertically suspended in the water, with the extremity of the snout at the surface, taking in air, which occasionally passed upwards in bubbles from the gill-openings and from the anus.

On some occasions, on being disturbed, it would rise from the bottom, quickly attain the surface, and almost immediately afterwards discharge a considerable amount of air from the anus.

Exp. 7.—Two specimens of *Anabas scandens**, the Common Climbing Perch of India, were placed in a glass jar, and a diaphragm of net fixed at about 1 inch beneath the surface of the water. Almost immediately on being placed in the water the fishes rose and attempted to reach the surface. They continued their attempts for about five minutes, striking vigorously against the net; they then sank down, and died in twelve minutes from the time they were prevented from having access to the surface of the water.

Exp. 8.—A specimen of *Trichogaster fasciatus* was placed in the same glass; and immediately after it had been observed to rise to the surface of the water the netted diaphragm was fixed half an inch beneath the surface—at 12 noon. Two minutes afterwards it again attempted to rise, but, being repulsed by the net, swam about, seeking for some means of exit. During the succeeding hour it frequently rose towards the surface and struck violently against the net and the sides of the vessel, the respiration becoming much affected, the gill-covers moving very rapidly. At 3 P.M. the fish lay at the bottom of the jar on its side; at 3.20 P.M. it again attempted to reach the surface, but had lost the power of maintaining its equilibrium, and moved convulsively about with the abdomen upwards; at 3.30 P.M. it lay expiring at the bottom of the jar.

The net was now removed; and the fish succeeded by a violent effort in reaching the surface of the water, when it quickly drew in some air and again sank to the bottom. It appeared much revived, but still lay with the abdomen upwards. Soon afterwards it rose again to the surface, and remained suspended vertically in the water with the extremity of the snout at the surface, and continued in this position for some minutes. Again it sank downwards, but appeared better able to maintain its equilibrium. After rising several times to the surface the fish regained completely the power of maintaining its equilibrium, appeared nothing the worse for what it had suffered, and swam about as usual.

The same experiment was repeated with the same fish on the following morning. It was placed in pure well-aerated water. The same results took place; and it died in four hours and a quarter.

Exp. 9.—Placed a specimen of *Ophiocephalus striatus*, 11 inches long, in the glass jar, and fixed the netted diaphragm 1 inch beneath the surface of the water. After seven minutes the fish became uneasy, and frequently rose towards the surface, but was repulsed by the net. Five minutes afterwards it rushed with great force against the net, burst one of the meshes, and passed through it to the sur-

* The accessory respiratory organs of this fish are described in 'Owen's 'Anatomy of Vertebrates,' vol. i. p. 487.

face. Having accomplished this it remained tranquil, resting on the upper surface of the net.

The same fish was, on the following day, replaced in the same jar and the net strengthened. The animal remained tranquil for five minutes, then became uneasy and dashed about violently, several bubbles of air passing upwards from the gill-openings. Occasionally it would remain quiet at the bottom for one or two minutes, then become very uneasy, and struggle powerfully against the net. Half an hour after immersion the fish became even more energetic in endeavouring to break the net, but soon became weaker, and died in 1 hr. 10 min.

Repeated the same experiment with three smaller-sized specimens of the same species. Immediately after the diaphragm had been fixed the fish rose and attempted to reach the surface, striking violently against the net. They then sank to the bottom, and during the first half hour frequently renewed their attempts to reach the surface. One of the fishes thrust its head through one of the meshes of the net and was retained in that position. The other two died at the same time, in 1 hr. and 5 min. (lying at the bottom in 10 inches of water); the third fish (which was retained in the mesh of the net near the surface, above which it did not, however, get its mouth) died twenty-five minutes afterwards.

The experiment was again repeated. Two specimens of the same species were placed in about 6 inches of water, with a perforated metal plate half an inch beneath the surface. They struggled in precisely the same manner, and then lay at the bottom for some minutes, the gill-covers moving slowly and with difficulty. Struggled violently one hour after the diaphragm was fixed, and died in 1 hr. 35 min.

Exp. 10.—A specimen of *Ophiocephalus punctatus*, 4 inches in length, was placed in the same glass jar at 1.55 P.M.; at 2.10 P.M. it rose towards the surface and pushed against the net; at 3.30 P.M. it feebly endeavoured to reach the surface, but soon sank down exhausted. Respiration appeared to have entirely ceased; a large bubble of air passed upwards from its mouth; and it died three minutes afterwards.

Another specimen of the same species was subjected to the same experiment. The fish became much excited after being placed in the water, and swam about rapidly, striking against the netting for about two or three minutes. It then sank to the bottom and remained quiet. On being roused up ten minutes afterwards it again rose and made many energetic attempts to reach the surface, during which a bubble of air escaped from its mouth. It again sank to the bottom and remained there, the gill-covers moving very slowly. Death occurred in 4 hrs. 40 min. The mouth was widely opened towards the time of death.

Exp. 11.—At 11 A.M. placed a specimen of *Mastacembelus pancalus* and one of *Rhynchobdella aculeata* in the glass jar, fixing the netted diaphragm as in preceding experiments. Both the fishes made several attempts to reach the surface; the *R. aculeata* nearly suc-

ceeded in pushing its body through the net at 3.30 P.M.: at 4 P.M. the same fish remained in a vertical position, having its head thrust through one of the meshes of the net, but not at the surface of the water. At the same time the *M. pancalus* lay on its side, moving the gill-covers with difficulty, and in fifteen minutes afterwards it died; twenty minutes afterwards, at 4.35 P.M., the *Rh. aculeata* died also.

A specimen of *M. pancalus* placed in water with free access to the surface was, at the time of death of the other two, as lively as in the morning.

I kept specimens of both *Anabas scandens* and *Trichogaster fasciatus* in an aquarium in my house at Calcutta for many months, and had constant opportunities for observing their habits. Two specimens of the *Anabas* which had lived in the aquarium from September 1871, were in April 1872 sent by me to the Gardens of the Royal Zoological Society of Ireland. Dr. Isidore Bourke, Surgeon H.M. British Forces, kindly undertook the care of the fish on their way home, and succeeded by great attention in bringing both alive to Dublin. One died three months after arrival, from an injury; the other lived for nine months, and then succumbed to the cold. I am quite satisfied that had the water of the aquarium in which the fish lived in the Dublin Zoological Gardens been kept at a temperature of 75° Fahr., or at least not permitted at any time to fall below 60°, the surviving specimen would have lived (if otherwise uninjured) for many years.

The habits of *Anabas scandens* and *Trichogaster fasciatus* are very similar. Both suddenly rush to the surface, discharge the vitiated air and take in a fresh supply instantaneously, immediately sinking to the bottom, where one or two bubbles of air may often be seen to escape from the gill-openings as if taken in excess. The action of discharging the air from the branchial cavities and taking in a fresh supply is accomplished so rapidly that it is impossible to say whether the used-up air is discharged before the fresh supply is taken in, or displaced by the incurrent stream of air. All that can be seen is, that when the fish places its mouth at the surface of the water a great quantity of air bubbles up about its head.

The *Trichogaster* appears to use the long filiform ray to which the ventral fin is reduced as a tentacle, moving it about towards any passing object. I have often seen one of these fishes move forward this ray and touch with it another fish slightly in front and on the same side, while the ray on the other side remained perfectly motionless directed backwards. Like the *Anabantes* they are fond of chasing one another round and round; and while so engaged the independent action of the single-rayed ventral fins as tentacles may be well seen.

The number of visits to the surface appears to depend, as might be expected, on the amount of muscular action accomplished by the fish, and on the temperature of the water; thus, when actively engaged in chasing one another, and in very warm weather, the visits were very frequent, sometimes three or four times in five minutes. Of all the fish experimented upon the *Anabas* went oftenest to the

surface, and consequently was soonest asphyxiated when retained under water *.

The faculty of living out of water, or when the gills are kept in a moistened condition only, not only for hours, but in some cases for days, possessed by many species of *Symbranchidæ*, *Labyrinthici*, and *Ophiocephalidæ* especially, is not alone a wonderful provision of nature enabling these animals to resist the prolonged droughts of the countries they are found in, but is also of the greatest importance to the inhabitants of these countries, who are well acquainted with their vitality out of water, and take advantage of it in transporting them long distances, and in being able to maintain their supply fresh till required for use. Accordingly these fish, though not very delicate in flavour, are highly esteemed by the people of Bengal, especially by the poorer classes, and great quantities of *Anabas scandens*, *Trichogaster fasciatus*, *Ophiocephalus punctatus*, *O. striatus*, and *Amphipnous cuchia* are daily exposed for sale in the bazars.

The *Anabas*, which has the greatest vitality of all out of water except the *Amphipnous*, is kept in closely woven baskets, about one hundred individuals or more in each basket. Thus lying close together, evaporation is greatly lessened and their gills are kept moist. In this condition they live, I have been told by many native fishermen, for four or five days. In very dry weather some water is daily thrown on them, or the basket is immersed for a short time in water.

A constant supply of fresh fish is thus afforded, the importance of which can only be fully appreciated in tropical countries, where fish taken in the morning are often unfit for use by breakfast time.

The experiments here recorded were but the commencement of what I had intended to be a series, including every Indian freshwater fish possible to procure alive. They were undertaken at the suggestion of Mr. Francis Day, to whose most interesting paper on this subject I have referred above. My investigations were suddenly interrupted by my unexpected return to Europe; and as I now see no prospect of revisiting the East Indies for some years, I think it may be well to record the few observations made.

The following Table (p. 321) exhibits the results of the experiments above described, and also of Mr. Day's investigations. The species of fish are arranged according to the time required to produce asphyxia when deprived of access to the surface of the water. The position of *Amphipnous cuchia* is uncertain.

* As remarked by Mr. Day (*loc. cit.* p. 279), some fishes which take in air at the surface of the water (compound breathers), possess the power of remaining in a state of semitorpidity at the bottom, and in this condition exist for many hours without respiring. This will account for the difference of time required to produce asphyxia in individuals of the same species noted in foregoing observations.

Number.	Names of Fishes.	Time required to cause asphyxia.		Lived without water.	
		In foregoing observations.	In Mr. Day's experiments.	In foregoing observations.	In Mr. Day's experiments.
1.	*Anabas scandens*	12 minutes.	Not determined.	Not determined.	24 to 26 hours.
2.	*Plotosus canius*	1 hour.	,,	,,	Not determined.
3.	*Ophiocephalus striatus*.....	1 hr. 5 min. to 1 hr. 35 min.	,,	,,	16 hours.
4.	—— *punctatus*	1 hr. 38 min. to 4 hr. 40 min.	1 hr. 21 min. to 1 hr. 28 min.	,,	3 hr. 25 min.
5.	*Saccobranchus singio*	2 to 4 hours.	Not determined.	,,	Not determined.
6.	*Trichogaster fasciatus*	3 hr. 40 min. to 4 hr. 15 min.	,,	,,	,,
7.	*Amphipnous cuchia*	Not determined.	,,	Five days.	,,
8.	*Mastacembelus pancalus*	5 hr. 15 min.	,,	Not determined.	,,
9.	*Rhynchobdella aculeata*	5 hr. 35 min.	,,	,,	,,
10.	*Platacanthus agrestis*	Not determined.	8 hours.	,,	,,
11.	*Lepidocephalicthys balgara* ..	24 hours.	Not determined.	,,	,,
12.	*Macrones tengara*	8 hrs. 20 min.	Water-breathers, not affected by being prevented from reaching the surface of the water.	,,	,,
13.	*Puntius stigma*	Not determined.			
14.	*Amblypharyngodon jerdoni* ...	,,			